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EVALUATION OF A CABLE-NET ROOF MODEL FOR HASTY FUEL STORAGE RESERVOIRS

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Army Mobility Equipment Research and Development Center
Fort Belvoir, Virginia

November 1972

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U. S. ARMY MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

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13 ABSTRACT

This report covers the testing and evaluation of a cable-net roof model to determine its suitability for eliminating rainwater from the top surface of hasty fuel storage reservoirs.

The roof model was field tested under simulated and actual rainfall conditions. The test showed that the weight of water from heavy rainfalls that could collect on the roof surface caused the deadman anchors to creep, and as a result the cable structure sagged The rainwater had a tendency to accumulate in the span between cables before cascading occurred, since the direction of water runoff was perpendicular to the position of the main suspension cables.

Details of illustrations in this document may be better studied on microfiche.

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Task 1J664717DL4103

November 1972

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SUMMARY

This report covers the testing and evaluation of a cable-net roof model to determine its ability to prevent rainwater from collecting on the top surface of hasty fuel storage reservoirs.

The roof model was field tested under simulated and actual rainfall conditions. The test showed that the weight of water from heavy rainfalls that could collect on the roof surface caused the deadman anchors to creep, resulting in sagging of the cable structure. The rainwater had a tendency to accumulate in the span between cables before cascading occurred, since the direction of water runoff was perpendicular to the position of the main suspension cables.

This is an interim report; work is continuing on techniques for elimination of rainwater from hasty fuel storage reservoirs.

FOREWORD

The testing and evaluation covered by this report was conducted under the general authority of Project 1J664717DL41, POL Distribution Systems. The work was accomplished in conformance with specific requirements of the Task DL4103, Bulk Fuel Storage.

The period covered is February 1971 through May 1971.

This project was under the general supervision of John D. Grabski, Chief, Fuels Handling Equipment Division, and under the direct supervision of N. A. Caspero, Chief, Onshore Fuel Systems Branch.

The following personnel participated in the test program: Joe Medrano, Project Engineer; Warren Parrish, Test Leadman; Robert Casteel, Test Mechanic; and Richard Clement, Former Test Mechanic.

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FOR HASTY FUEL STORAGE RESERVOIRS

I. INTRODUCTION

1. **Background.** The hasty bulk fuel storage reservoir is a new item of equipment developed by the U. S. Army Mobility Equipment Research and Development Center (USAMERDC). The reservoir, with a capacity of 25,000 barrels, is intended to provide bulk storage facilities until permanent storage can be constructed. When filled to capacity, the top dimensions are 92 feet wide by 185 feet long, and the depth is 13 feet. The storage facility is designed to be suitable for operation under all environmental conditions except polar and arctic.

Rainwater which accumulates on the top surface of the reservoir must be removed or eliminated to prevent operational problems. The water, which has a greater density than fuel, tends to migrate to a level beneath the top surface of the fuel and interferes with fuel storage operations.

In order to remove rainwater from the top surface of the reservoir, a dewatering system was tested on September 1970.[1] The system consisted of tubes, hoses, and pumps positioned longitudinally along the top surface of the tank. The test showed that many factors in the dewatering system prevented successful dewatering operations of hasty fuel storage reservoirs under field conditions, and the technique was not considered practical.

Several concepts of covers for the reservoir were investigated, but a cable-net roof was thought to be least costly and would require minimum operational maintenance for a storage installation. It was also felt that a scale model roof would not be representative of the load forces involved, so a full-scale section was analyzed to determine the practicability of the concept.

2. **Objective.** The objective was to determine the feasibility of using a network of cables to support a coated fabric membrane (Fig. 1) and provide shelter from the elements for hasty fuel storage reservoirs.

[1] Medrano, Joe, "Evaluation of a Dewatering System for Hasty Fuel Storage Reservoirs," USAMERDC Report 2040, October 1972.

Fig. 1. Model concept of cable-net roof.

T6263

II. INVESTIGATION

3. **Description of Material.** A section of a cable-net roof, one-fifth the actual length of the fuel storage reservoir, was prepared for testing. In order to simulate a reservoir installation, two parallel berms, 8 feet high and 110 feet apart, both having a 5-percent slope toward one end, were constructed (Fig. 2). A deadman anchor consisting of a 24-foot section of 8-inch diameter pipe was buried underneath each berm. Attached to each deadman anchor were seven short lengths of cable spaced 4 feet apart to provide tie-down for the main cables (Fig. 3). Seven main cables 5/8 inch in diameter and 115 feet long were strung between the berms (Fig. 4). A heavy-duty turnbuckle was attached to one end of each cable in order to tighten the cables. On the berm underneath each main cable, an aluminum breastplate was placed to prevent the cables from cutting into the top edge of the berm (Fig. 5).

After the cables were installed spanning the reservoir between the berms, a section of coated fabric 20 feet long by 110 feet wide was installed over the main cables and anchored down (Fig. 6). Small-diameter cables (1/8 inch in diameter) were then installed at four-foot intervals perpendicular and over the main transverse cables to offer additional support for the coated fabric. In addition, 1/8-inch-diameter cables were installed at 8-foot intervals over the top surface of the coated fabric to prevent an upward lift of the roof from wind forces (Fig. 7).

4. **Details of Test.** All main cables were tensioned to 3000 pounds by using a "come-along" tensioning device. The edges of the 20-foot length of the fabric cover were pulled and tied down tightly to remove all slack from the fabric. All small-diameter cables perpendicular to the main cables were tensioned sufficiently to support the weight of the roof fabric in the span between each main cable. Dynamometers were installed on the main cables to measure cable tension.

a. **Evaluation of Roof under Simulated Rainfall Conditions.** Rainfall was simulated by spraying water over the entire surface of the roof section using a 2-inch firefighting nozzle and hose attached to a pump and a tank trailer (Fig. 8). The rainfall simulated was a rate of approximately 2 inches per hour for a period of 30 minutes.

The test showed that water would run off the roof section when the main cables were tightly tensioned. As soon as the weight of water on the top surface of the roof caused the main cables to sag, isolated puddling occurred in the span between the main cables (Fig. 9). The small-diameter longitudinal cables became slack and offered little support to the coated fabric roof. Water was able to cascade over the roof areas across the main cables after a large puddle had formed (Fig. 10). Two main cables were deliberately slackened to 2500 pounds tension during the test to

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Fig. 2. Construction of berms 110 feet apart.

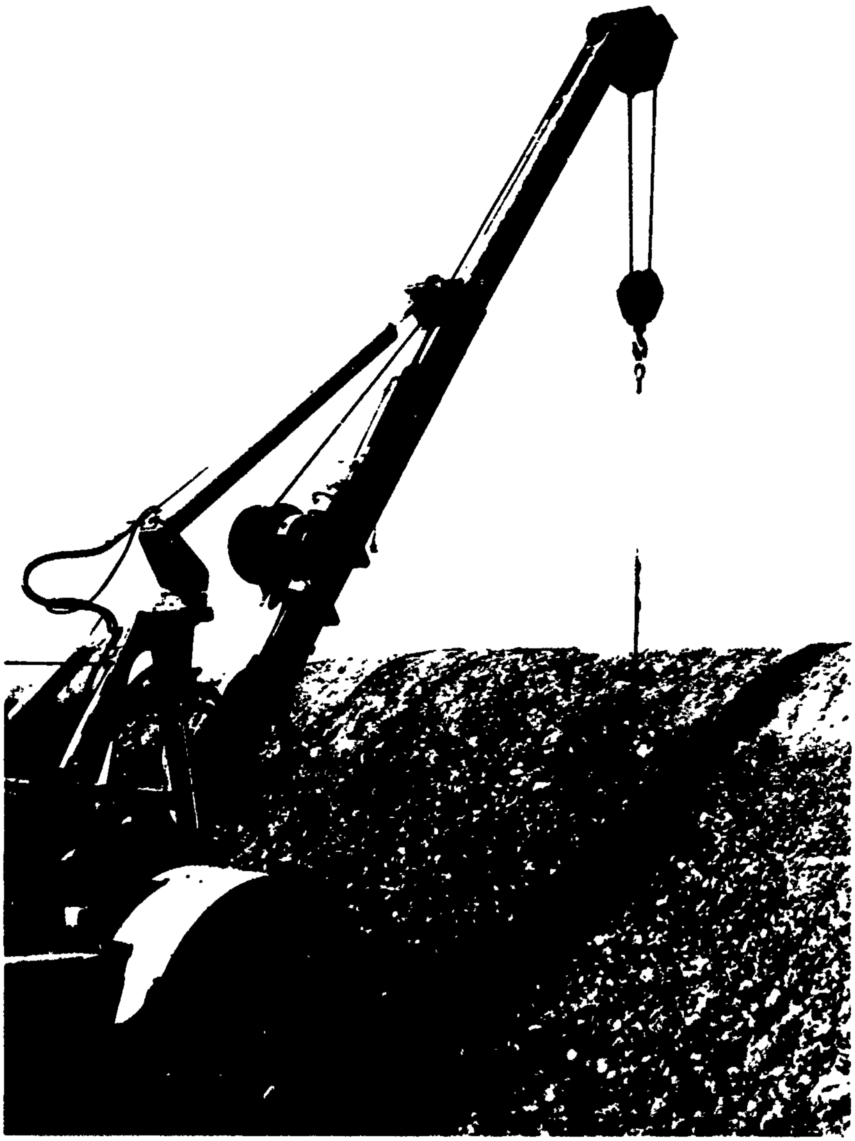
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Fig. 3. Tie-down cables being pulled through berm.

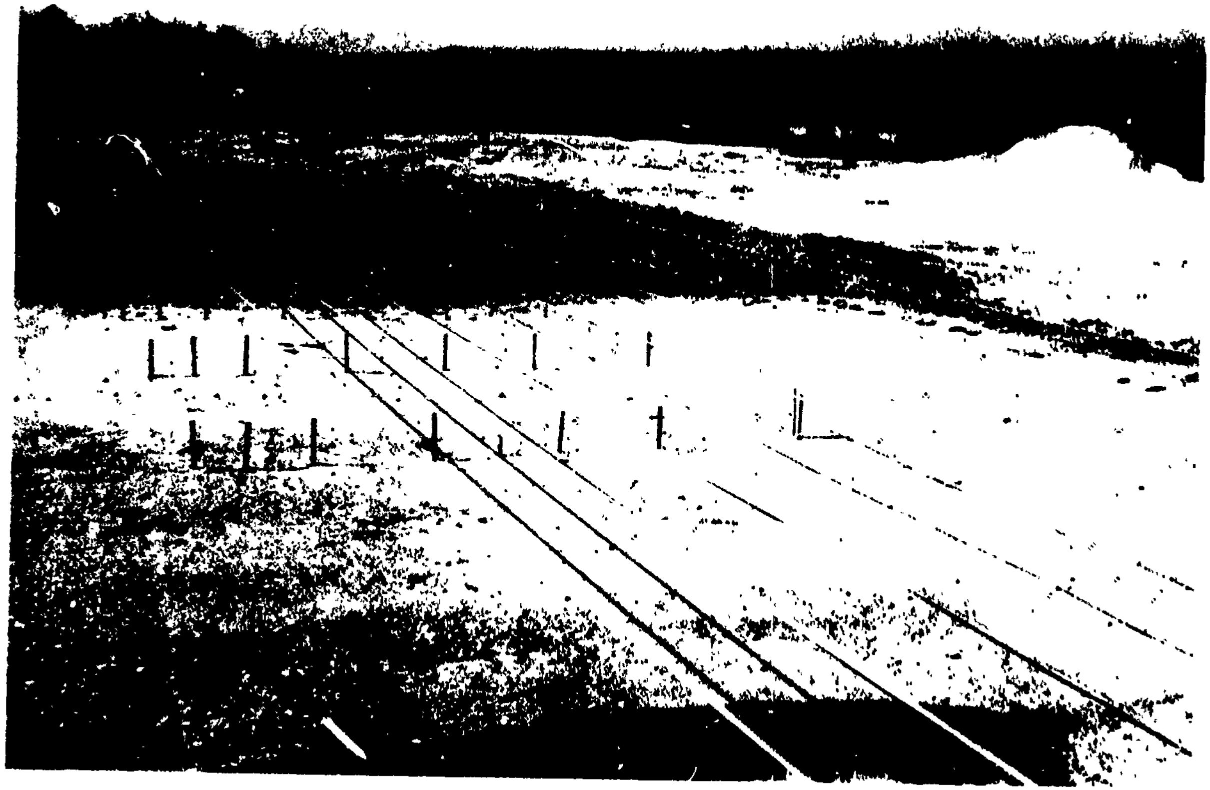

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Fig. 4. Installation of main cables between berms.

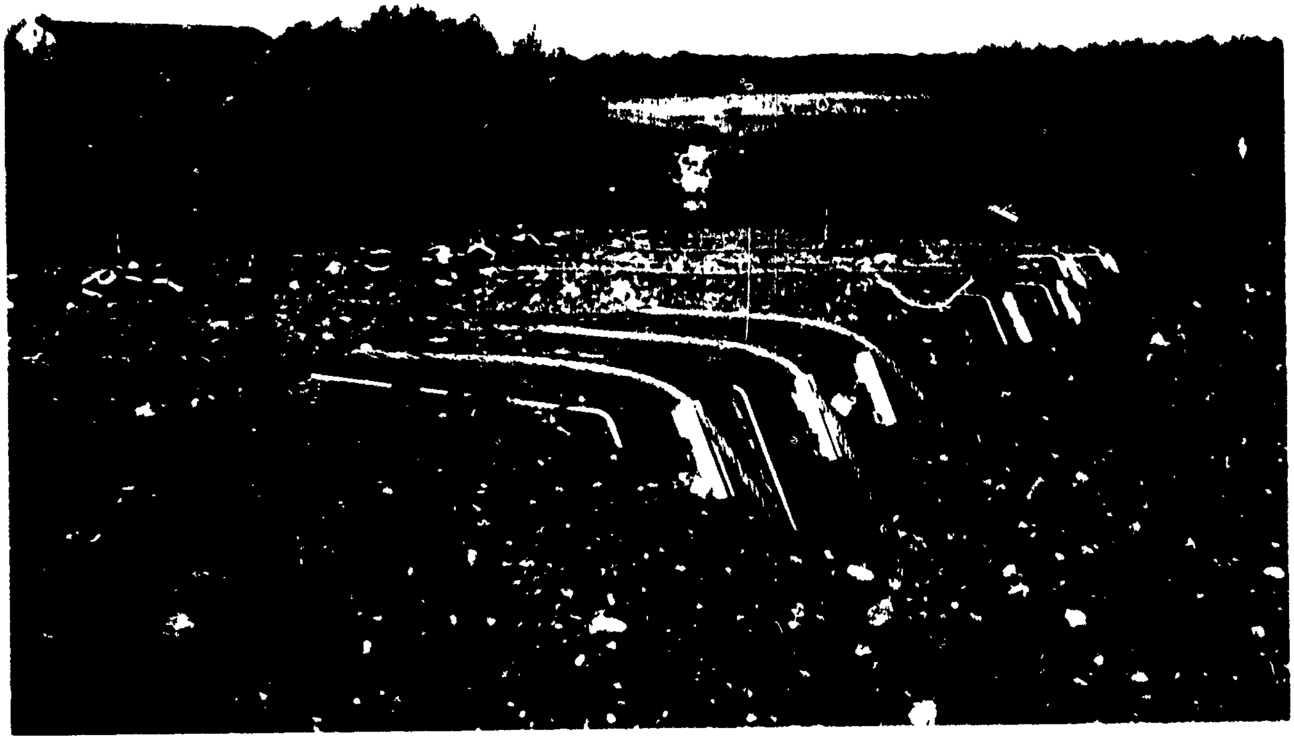

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Fig. 5. Installation of breastplates under cables.

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Fig. 6. Coated fabric covering over cable structure.

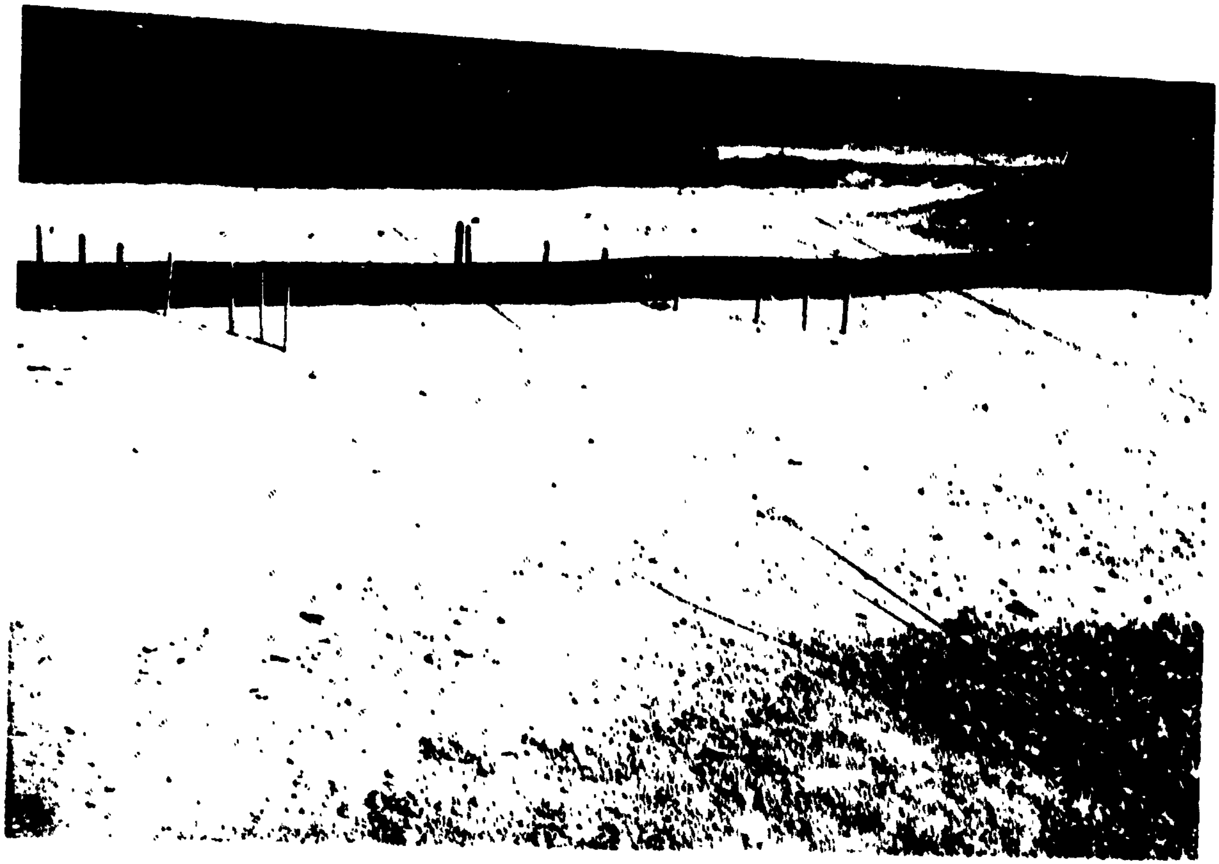

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Fig. 7. Roof section showing small-diameter cables and anchors

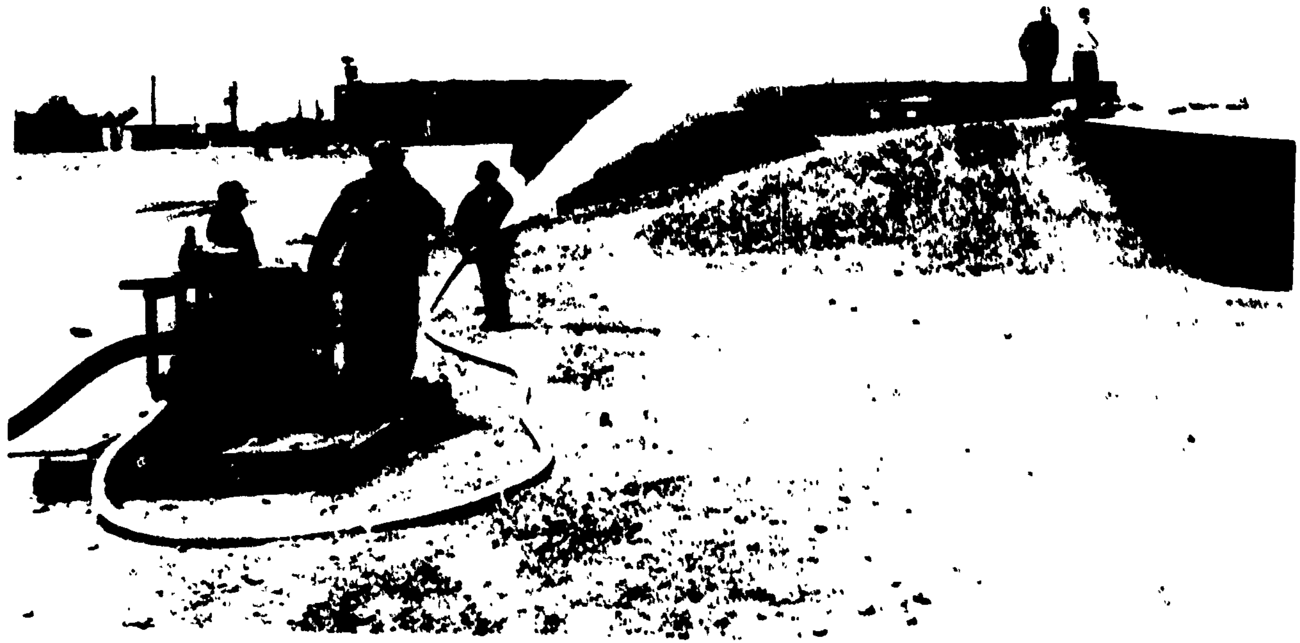

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Fig. 8. Rainfall simulation.

T8335

Fig. 9. Water puddles on roof surface between main cables.

Fig. 10. Accumulation of water in span between main cables.

determine the effect on water runoff, and it was noted that puddling occurred and water was unable to run off.

b. Evaluation of Roof under Actual Rainfall Conditions. During the testing period, 1¼ inches of rainfall fell on the roof during a 1-hour period. All cables were tensioned and the roof fabric was kept taut.

The test showed that water accumulated at the lower end center area of the roof. Rainwater started cascading over the end main cable when the water level in the puddle got over the height of the cable. Creepage of the deadman pipe anchors buried beneath the berms was noted when a large water puddle accumulated on the roof. The small-diameter longitudinal cables became slack and offered little support to the coated fabric roof, as they had during previous tests.

III. DISCUSSION

5. Discussion. Testing was conducted for a limited period of time. Extended testing under adverse weather conditions of heavy rainfall or snow accumulations was not carried out.

The effects of wind forces on the section of roof were not precisely determined. During the test, high wind forces caused considerable flapping and displacement of the roof fabric. The wind blew under the roof between the two berms, which would not have happened in an operational installation.

It was difficult to maintain the proper tension on each main cable. Since high anchor loads are required, a deadman or earth anchors will creep and cause the cables to gradually become slack. The holding power of an anchor depends on the firmness of the soil into which it is placed rather than on the depth of the installation. Therefore, since the berms for the reservoir are built of compacted earth, the holding power of a deadman or anchor will be reduced. A heavy concrete revetment would be the desirable anchoring method, but it would not be practical for a hasty fuel storage reservoir installation.

Originally, it was thought that deflection of one main cable would not affect water runoff seriously, since the weight of the fabric and rainfall would be distributed to the adjoining main cables and small-diameter cables underneath the roof. But since the direction of water runoff is perpendicular to the main cables, it was found that deflection on any cable will cause rainwater puddling to form before cascading. The excessive weight of the rainwater puddles on the top roof surface will cause the deadman or earth anchors to creep.

IV. CONCLUSION

6. **Conclusion.** The size of the section of roof constructed was adequate for evaluation of the concept. The test showed that inadequate water runoff from the top surface of the roof was due to the formation of puddles between the main cables.

Since the direction of water runoff was perpendicular to the position of the main cables, rainwater had a tendency to accumulate in the span between cables before cascading. As soon as rainwater accumulated on the roof surface, the weight of the accumulations forced the anchors to creep, which caused the cables to sag. The span of the reservoir (110 feet) is considered to be too large for practical anchors or a deadman to provide sufficient holding power to prevent the main cables from sagging during a heavy rainfall.